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ИССЛЕДОВАНИЕ ВЛИЯНИЯ ПАРАМЕТРОВ ЛАЗЕРНОЙ СВАРКИ НА МИКРОСТРУКТУРУ И МЕХАНИЧЕСКИЕ СВОЙСТВА Al–4,7 % Mg–0,32 % Mn–0,21 % Sc–0,09 % Zr СПЛАВА

В работе исследовано влияние пиковой мощности (0,64–1,31 кВт) при напряжениях из диапазона 330–430 В при лазерной сварке со стандартным диаметром пучка и длительностью импульса 8 мс. Изучена микроструктура, сформированная сваркой. Установлено, что существует разноообразие в размерах и форме зерен в зоне шва. Показано, что с увеличением пиковой мощности ширина и глубина области шва увеличивается.

Ключевые слова: деформируемые алюминиевые сплавы, лазерная сварка, пиковая мощность, микроструктура.

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INVESTIGATION OF INFLUENCE OF PARAMETERS OF LASER WELDING ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF Al–4.7 % Mg–0.32 % Mn–0.21 % Sc–0.09 % Zr ALLOY

In the present work the influence of peak power of laser beam welding were studied at voltage range from 330 to 430 V and peak power (0,64; 0,75; 0,87; 1,01; 1,15; 1,31) kW , and laser beam diameter is standard and duration 8 ms. The microstructure after welding was studied. It was concluded that there is a variant in grain size and shape in the welded zone and pre-welded area. The dimensions of welded zone was measured. From measuring data, it was observed, that as increasing the peak power the width and depth of welding increased.

Keyword: deformed aluminum alloy, laser welding, peak power, microstructure.

Al–Mg alloys have been widely used in the field of food handling and chemical processing industries because of their attractive comprehensive properties such as medium strength, high ductility and excellent corrosion resistance [1–4]. The strength of these alloys is primarily due to solid solution strengthening by Mg, which has a substantial solid solubility in aluminum. However, in order to broaden the application in automotive and aerospace

industries, alloys with higher mechanical strength are required. An effective approach to improve the strength of aluminum alloys, including our experimental Al–Mg alloys, is the addition of scandium as an alloying element [5–6]. The strengthening mechanism of Al-alloys with Sc addition has been frequently reported to be the presence of Nano-scaled coherent Al3Sc particles that precipitated from supersaturated α-Al matrix during aging treatment or thermo-mechanical processing [7–12]. For the cast ingots, on the other hand, the formation of primary Al_3Sc particles also helps refine the microstructure, which improves both the strength and formability. However, such effect shows up only when Sc addition reaches eutectic composition [13–15]. Owing the great contribution of grain refinement, much of the work on the Al_3Sc primary particles found in aluminum alloys containing a high level of scandium have been carried out in numerous studies [16–17].

The material used in the present work was 1545 K alloy with the chemical composition presented in Table 1. This alloy from a 280-mm-thick industrial ingot, sheets with thicknesses of 10 mm. The 10-mm sheets were rolled to a thickness of 1 mm using a laboratory rolling mill. Heat treatment was performed using a "Nabertherm" furnace with a temperature accuracy of ± 1 °C.

We used technology involved only cold (at room temperature) rolling with one intermediate annealing step at 250 °C for 1 h , and then prepared it by Struers (grinding and polishing equipment) and then did oxidation process to obtain good photos of microstructure by microscope Neophot-30.

Table 1

Chemical composition of the investigated alloy 1545 K, mas. %

Al	Mg	Mn	Sc	Zr	Be	Cu	Fe	Zn
bal.	4.7	0.32	0.21	0.09	0.001	<0.1	<0.1	<0.1

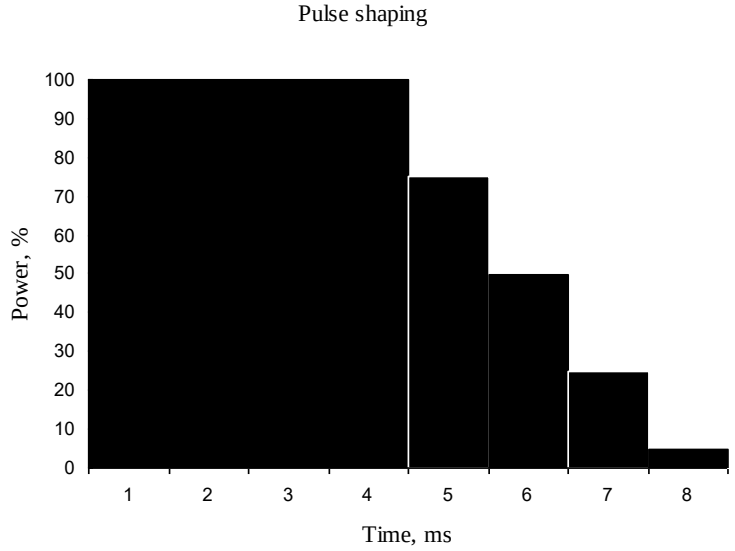


Figure 1. The form of pulse shape

Table2 shows the results of width and depth after welding with different voltages (330, 350, 370, 390, 410, 430 volt) and the beam diameter is standard. Print tracks at a constant pulse duration of 8 ms, a constant rate of movement of table 1 mm/sec, a constant overlap of 0,1 mm, and the pulse shape in the next figure.

Table 2

Results of width and depth after welding with a parameters peak power and voltage

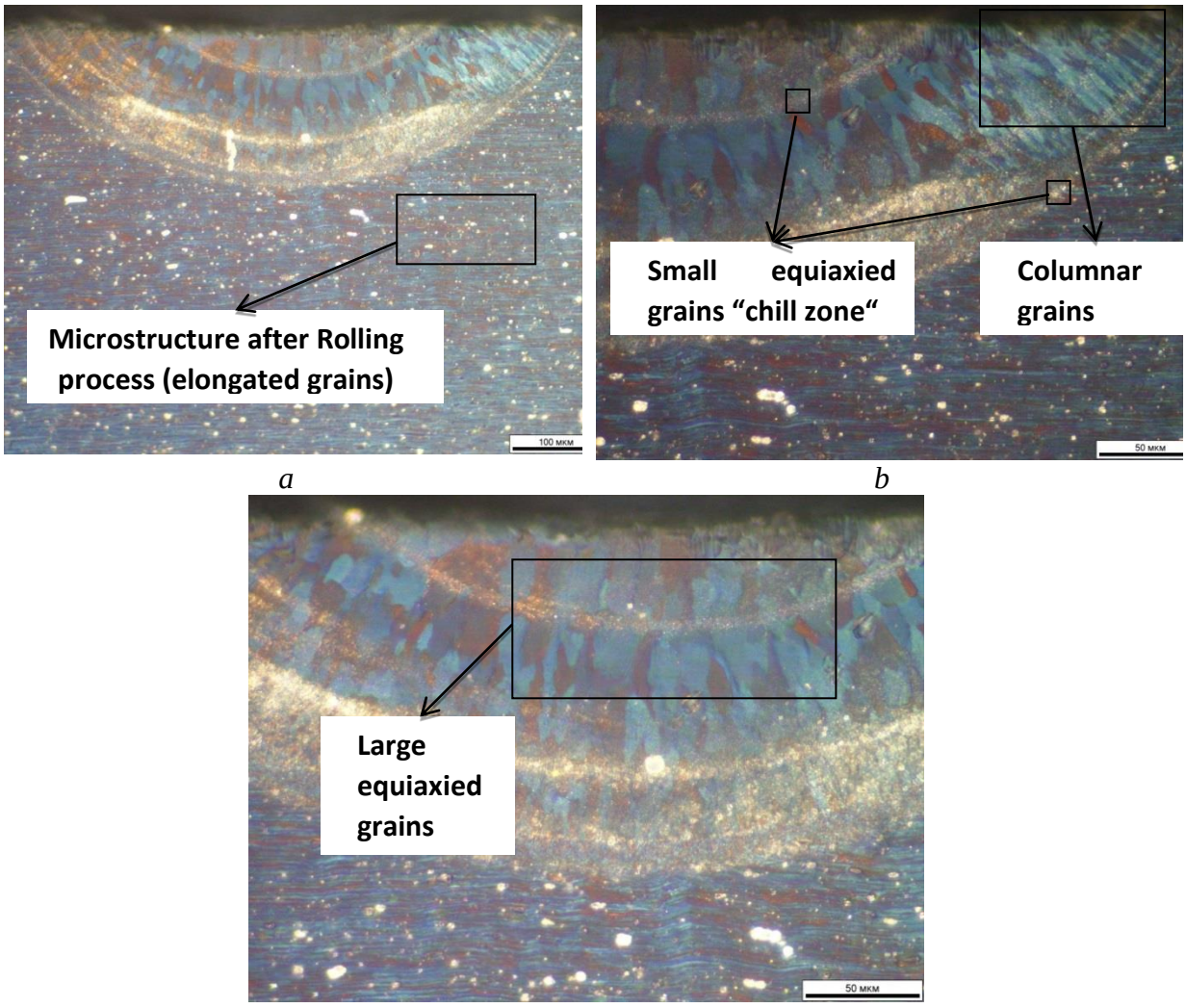
No. track	Voltage, V	Peak power, kW	Depth, mm	Width, mm
1	330	0,64	55,0	386,6
2	350	0,75	71,5	401,9
3	370	0,87	105,9	491,0
4	390	1,01	132,1	626,3
5	410	1,15	182,3	701,2
6	430	1,31	235,7	730,0

After laser welding a samples were prepared and obtained the microstructure of welded zone by oxidation process. The photos are presented at figure 2.

From the previous figure 2, we can observed that after cold rolling the material have elongated grains due to plastic deformation and after laser welding this grains transformed to various shape of grains like small equiaxed ‘chill crystals’, columnar and large equiaxed grains due to the direction of heat.

Small **equiaxed grains** (**chill crystals**) form at this stage. Latent crystallization heat, liberating from the crystallizing metal, decreases the undercooling of the melt and depresses the fast grains growth. At this stage some of small grains, having favorable growth axis, start to grow in the direction opposite to the direction of heat flow. As a result **columnar crystals (columnar grains)** form. Length of the columnar grains zone is determined by the **constitutional undercooling**. When the temperature of the fusion weld, adjacent to the solidification front, increases due to the liberation of the latent heat, constitutional undercooling will end and the columnar grains growth will stop. Further cooling of the molten alloy in the central zone of the ingot will cause formation of **large equiaxed grains**.

Finally, from the figure 3 as seen as peak power increases the depth and width of welded zone increased.



a *b*

c

Figure 2. Some microstructures of 1545 k alloy after laser welding with parameter peak power (*a*, *b* and *c*)

Conclusion

1. The material used in the present work was 1545 K alloy, we make laser welding process with voltage from 330 to 430 Volt, and different peak power (0,64; 0,75; 0,87; 1,01; 1,15; 1,31) kW, and laser beam diameter is standard and duration 8 ms.

2. Obtained microstructure photos are shown the welded area and measured the dimension of welded area to choose the suitable voltage and peak power to weld this material, and get the shape of grains ofter welding and discuss it. And, it was observed, that as increasing the peak power the width and depth of welding increased.

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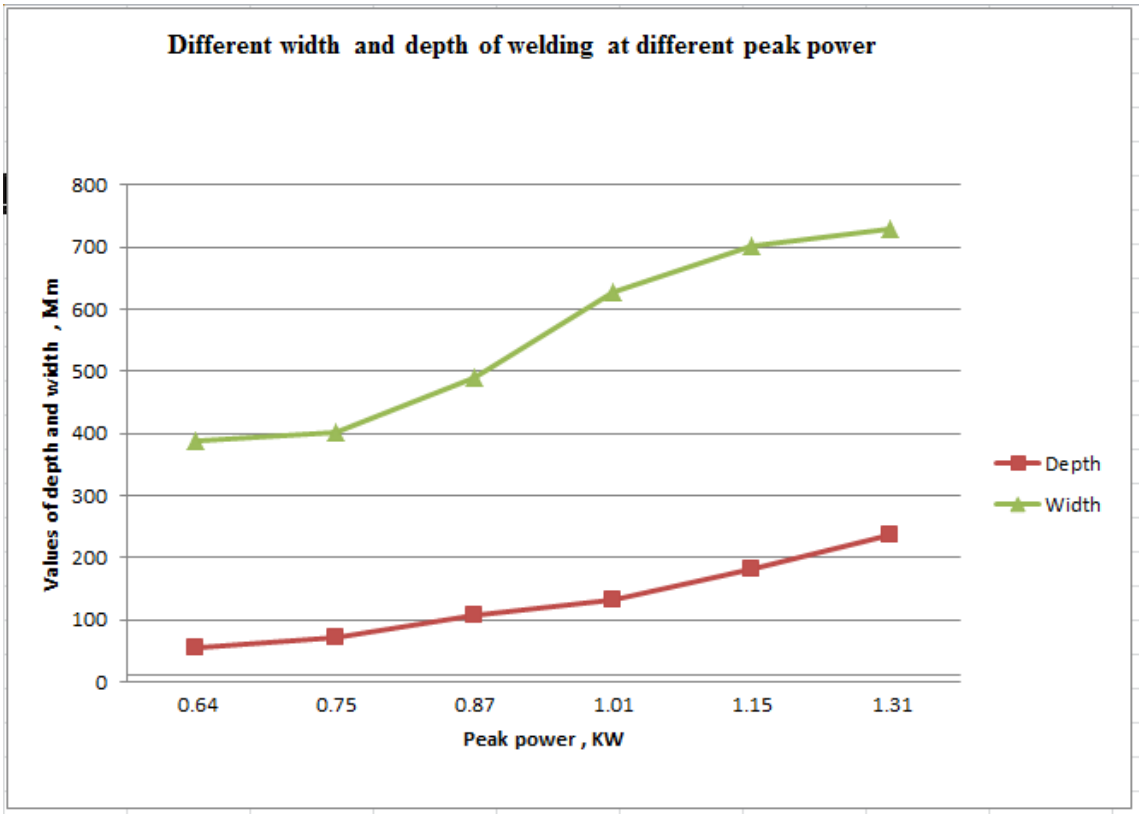

Figure 3. Different width and depth of welding at different peak power

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